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RESEARCH ARTICLE

Transition to Holacracy and Digital Supply Chain Management

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ABSTRACT

Digitalization offers great opportunities for improving supply chain management. However, its full potential is limited by the tendency of managers in these chains to rely on hierarchical organizational structures, which prevent the full utilization of employees' competencies. These competencies are necessary for the creation and use of artificial intelligence that operates on both physical and non-physical management objects. The solution to this problem can be achieved through holacracy, which creates conditions for employees in supply chain links to act as "sensors" and "actuators". These roles are essential for the development and implementation of a digital twin that can help manage these chains. The purpose of this article is to create theoretical and methodological prerequisites for the use of holacracy in digital supply chain management.

To achieve the purpose of this article, we used terminological analysis, descriptive and faceted methods, or a TDF methodology. The article explains the essence of holacracy and the digitalization of supply chain management. It discusses digitized options for supply chains, as well as developed technologies for the interaction of persons involved in digital supply chain management in a holacratic environment. The article also justifies the approach to developing digital management solutions for supply chains based on holacracy.

Keywords: holacracy; digitalization; management; supply chain; enterprise; relationships; process; resource flow; management decision; technology of interaction

1. Introduction

Digitalization is pervading many spheres of human life everywhere. But while spheres operating with physical objects are quite easy to digitize, spheres focused on managing non-physical objects face significant difficulties in developing and implementing digital technologies and tools. Supply chain management is one of these spheres. Unlike other spheres of human activity, supply chain management has the following features:

Firstly, there are not one, as in most scientific disciplines, but four complex management objects simultaneously: enterprises[1], relationships[2] between them, processes[3], and resource flows[4].

Secondly, there is a clear bias in the study and digitization of these objects. Supply chain management primarily focuses on processes (e.g.,[5]), but researchers unjustifiably neglect the remaining three objects of

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management: enterprises, relationships, and resource flows. This aspect significantly affects the effectiveness of supply chain management (e.g.,[6,7]), including its sustainability.

Thirdly, the diversity of physical (machine tools, transport, warehouse equipment, inventory, etc.), as well as non-physical (values, ideas, projects, strategies, plans, relationships, powers, responsibilities, management decisions, etc.) management objects[8], as well as their versions and variants.

Fourthly, the presence of a large number of organizationally isolated entities, including autonomous economic entities (links in the supply chain), and, consequently, a real threat of opportunistic behavior by these entities[9], etc.

These features, together and simultaneously, cause many supply chain management issues that can be addressed through digitalization, which provides significant competitive benefits for their links[10]. One such benefit is the improvement in the quality of management decisions made in supply chains (e.g.,[11,12]). However, these decisions are made at different levels or circles within the organizational structure and therefore need to be developed and implemented by various management entities using a systematic approach. The solution to this problem is possible through the use of holacracy[13]. Holacracy is a decentralized management structure. It consists of teams called “circles” in which individuals have multiple roles, and “lead links” carry leadership functions[14]. This leaderless structure allows immediacy in time and place and increases responsiveness[15]. Holacracy is a natural stage in the evolution of management and has received additional impetus in the context of digitalization.

The hypothesis of this study is that it is possible to improve the efficiency of supply chain management through the use of holacracy. Holacracy provides for decentralizing the development and implementation of management decisions within organizational structures (e.g.,[16,17]). At the same time, the results of decisions made by multiple management entities can be improved based on digital technologies and tools, in particular, digital twins of supply chain management (e.g.,[18,19]). Digitalization leads to a decrease in the complexity of management tasks and, consequently, a decrease in management staff, with the delegation of their responsibilities to lower levels of management. This is in line with the principles of holacracy.

The novelty of this study is due to the peculiarities of non-physical supply chain management objects, the digitalization of which will allow for the creation of artificial intelligence that operates not only with physical, but also non-physical management objects. If this intelligence is created, it will be possible to develop management decision support systems (e.g.,[20]) aimed at minimizing lost profits. Management decision support systems, designed as digital twins of supply chain management, should expand the potential of holacracy, preventing possible chaos that scientists and professionals fear[21].

The creation and use of artificial intelligence operating on non-physical objects is possible if the terminology of supply chain management is revised. If artificial intelligence operating on physical objects is based on quantitative data linked by numerous dependencies, then artificial intelligence operating on non-physical objects should use their classification features and dichotomies to form identification series. The basis of this artificial intelligence is a network of terms arranged according to a systematic basis. This allows this intelligence to move from the term of one non-physical object represented as a standard to the standard for the term of other non-physical objects. Thus, prerequisites are created for modeling complex non-physical management objects, such as concepts, strategies, plans, management decisions, etc. Without solving this problem, it is difficult to justify the rigour of quantitative research methods. Before using them, it is necessary to specify which one of the more than 300 supply chain management terms will be used as the basis for the study.

A feature of artificial intelligence operating on non-physical objects is the problem of choosing one solution (of two or more) at the bifurcation points in the algorithms that form it, since non-physical objects, unlike physical objects, do not have sensors or actuators. For the stable operation of this type of artificial intelligence, it is necessary for the functions of these devices to be taken over by employees of the organization. Each employee may encounter a situation where one or more non-physical management objects, or their combination, are not adequate for the current management situation (such as the Toyota Andon system). This situation is formed by a unique set of physical and non-physical objects in the internal and external environment, and various combinations of their effects on each other are possible. Having correctly identified and digitized these objects using binary codes, the employee sends the information received to a software product based on artificial intelligence. The task of this artificial intelligence is to either select a well-known management decision or to model it using standards transformed into virtual copies based on the processing of additional classification features and dichotomies of non-physical objects, contributing to the uniqueness of the current management situation for a unique organization. This means that the Big Data system needs to be updated with information about various effective and ineffective management decisions implemented in various management situations. According to the information received from outside, artificial intelligence should be able to find the most effective management solution that can be adapted to a specific organization using artificial intelligence. Moreover, the final management decision can be automatically structured according to the levels and horizons of the organizational management structure, with delegation of authority, establishment of employee responsibilities, and allocation of necessary resources.

The objectives of this study are to clarify the essence of holacracy and the digitalization of supply chain management, as well as to develop a technology for interaction between persons involved in digital supply chain management in a holacratic environment. Additionally, we aim to substantiate an approach to making digital management decisions in supply chains based on the principles of holacracy.

2. Literature review

Most researchers rightly point out that the idea of holacracy based on decentralization and self-management in various types of organizations is not new[22]. Therefore, this study will focus not so much on the development of the theory and methodology of holacracy, but rather on identifying the prospects for its use in supply chains formed under the influence of the digitalization of non-physical objects in data chain management. Automation and computerization, or Industry 4.0, as well as digitalization and human-machine interaction, or Industry 5.0, and decentralization and self-management, or Industry 6.0, are all likely to displace many managers in various ranks. These changes will affect those managers who develop and implement management decisions that can be formalized, standardized, and digitized.

At the same time, while simplifying organizational structures in supply chain management, personnel will inevitably face the challenge of choosing and adequately responding to the needs of end users, and not just that. Therefore, it is advisable to agree with the opinion of TJ. Rau that “Holacracy gives more structure, sociocracy gives more choice”[23]. This aspect of the study is extremely important because it underlies the development and adoption of management decisions in conditions of holacracy[24]. Recall that “Sociocracy … is organized around four key elements: circular hierarchy, consent-based decision-making, double linking, and practices to foster inclusivity and voice”[25]. Unfortunately, the introduction of sociocracy is hindered by low levels of participation[26] and persistent inequalities within decision-making[27].

The problem of digitalization and holacracy in supply chain management is particularly relevant, since each link in this chain interacts with numerous suppliers and consumers or their fronts. The hierarchical structure of the supply chain links imposes serious restrictions not only on the relationships between these links, but also on the value desired by end consumers. If it is possible to implement holacracy, at least at the interfaces between adjacent links in supply chains, where each link takes into account its own interests, then it will be possible in the future to share the experience gained from this approach within the internal environment of those links.

Internet information and keywords “holacracy”, “sociocracy”, and “supply chain” were used to search, select, and analyze literary sources on the research topic on July 30-31, 2025. To solve these problems, we studied a list of the most popular publishing houses whose competence includes disseminating scientific literature. After examining the content of their online libraries, we selected 14 publishers. As a result of our study, we identified 16 relevant sources. We also conducted an additional search for literary sources related to our study topic on Google Scholar, which increased our list to 53 (**Table 1**).

In the studied literature:

Firstly, no research has been identified related to the implementation of the theory and methodology of holacracy in supply chain management;

Secondly, digitalization does not affect supply chain management (subject and management objects), but supply chains (management objects);

Thirdly, there are no recommendations for creating digital twins of non-physical supply chain management facilities, either in parts or in general.

Fourthly, the issues surrounding the terminology of holacracy remain unresolved, as the terms “sociocracy”, “spaghetti organization”, “management 3.0”, and “teal organization” (Khoury et al., 2024) are used in conjunction with this term. Researchers are attempting to differentiate not only between these terms but also to distinguish them from other terms associated with bureaucracy and post-bureaucracy[22,39,40].

Table 1. The results of the literature analysis of the research topic.

Publisher (source)	Number of articles	Articles relevant to the research topic	Digitalization	Supply chain
Springer	3	[28]	+	-
Taylor and Francis	2	-	-	-
Elsevier	3	[29]	+	-
Wiley	1	-	-	-
SAGE	1	-	-	-
Inderscience	1	-	-	-
Emerald	1	-	-	-
IEEE	2	[30]	+	-
MDPI	2	-	-	-
Google Academy	37	[31-37]	+	-
Итого:	53	-	-	-

Fifthly, despite the fact that holacracy mostly concerns the activities of individual organizations or the micro-level of the economy (e.g.,[29]), the possibility of its extension to macro-level objects is being studied[13,41].

Sixthly, although holacracy provides various benefits, including improved decision-making and autonomy[25,42,43], it poses challenges that require a strategic approach[30,44,45].

Seventhly, researchers are trying to measure the level of holacracy in organizations of various profiles[46-48].

Eighthly, the concept of holacracy is not well understood in modern academic literature[49]. Therefore, it is necessary to clarify the values of holacracy[50], find out its practical applicability[51], evaluate the capabilities, culture, and resources of the organization[37], and ensure thorough implementation and continuous adaptation of the organization to the external environment[14].

Ninthly, when implementing and using holacracy in organizations, it is advisable to: use the potential of senior management and leaders[52]; deeply understand their customers[53]; achieve a certain level of culture[15]; take into account the personal characteristics of employees[54]; pay special attention to human-organization interaction[55]; focus on employee training and adaptation[13,56]; improve organizational role allocation[51,57].

Tenthly, when improving holacracy, it is necessary to clarify its principles and factors of the internal and external environments of the organization[42]; improve innovative business strategies[58]; explore ways to implement changes in the structure of the organization[59]; promote organizational change[60], as well as to create a management records system[31].

Eleventhly, it is noteworthy that researchers associate the introduction of holacracy with digitalization, emphasizing its relevance at the macro level[33] and at the micro level of the economy[34]. In terms of supply chain management, they prioritize the digitalization of business processes[37]. If we compare a modern organization with a complex software system[32], it can be considered that "an organization, like a plane, is equipped with sensors—not lights and gauges, but the human beings who energize its roles and sense reality on its behalf"[13]. This comparison should be taken into account when creating digital twins of organizations[28]. At the same time, holacracy significantly affects the application software of organizations such as Glassfrog, holaSpirit, or Nestr[31].

The topic of digital twins in supply chain management is still controversial. On the one hand, in addition to the digital twin, its analogues are used: "digital model", "digital shadow"[61], "digital copy"[62]; and, on the other hand, digital twins are distinguished for products, manufacturing assets, and manufacturing processes[63]. In both the first and second cases, it is necessary to clarify the relations between analogues and variants of the digital twin of supply chain management. And not only to refine them, but also to digitize them. This will make it possible to introduce a systematic approach to the creation of digital twins of various types, used by specialists to manage supply chains using appropriate organizational structures[64].

The literature review on the study topic allowed us to formulate its main questions:

RQ1: What is the main difference between holacracy and other variants of link or supply chain management?

RQ2: How to digitize supply chain components and the management of these chains?

RQ3: What is needed to develop technology for interaction between persons involved in digital chain management in a holocratic environment?

RQ4: How to justify a holacracy-based approach to digital management decision-making in supply chains?

3. Methodology

To answer the above questions, methods of qualitative research are needed[65,66]. These methods include:

Firstly, terminological analysis. Before exploring and, even more so, optimizing a physical or non-physical object of study, it is necessary to identify and formalize it—that is, to determine and measure its quantitative parameters and qualitative characteristics. Moreover, during the optimization process, it is necessary to determine which parameters and characteristics of the object under study are most consistent with the goals of the study. It is no secret that many terms have been developed to identify and formalize the same study object. In a particular situation, one or another set of actual quantitative parameters and qualitative characteristics is relevant. Terminological analysis is most suitable for solving these problems.

Secondly, descriptive method. Not all actual qualitative characteristics of the object under study are equally important in an unstable external environment. In this regard, it is necessary to rank these characteristics, that is, to create identification series that most accurately describe the study object in a particular situation. These identification series are understood as a set of linearly ordered, limited in number, and time-varying classification attributes of one or more logically interrelated study objects that allow them to be measured both individually and collectively in order to select appropriate standards, create (virtual copies), perform computer modeling, and develop management decisions. The creation of series of this type, allowing not only to identify and formalize the non-physical object of study, but also to measure it, is the goal of the descriptive method of qualitative research.

Thirdly, it is a faceted method. The goal of this method is to establish relations between different versions and variants of the study object, as well as its horizontal and vertical relations with other objects adjacent to it. Using the faceted method, it is possible to create algorithms for managing non-physical management objects, on the basis of which an artificial intelligence operating on these objects is formed. Thus, the task of designing the digital twin becomes achievable not only for supply chains[18], but also for managing chains of this type. When creating it, the concept of holacracy should be used, since artificial intelligence requires a variety of “sensors” and “actuators”, whose functions, unlike physical management objects, are performed by employees of supply chain links[13], as mentioned earlier. In conditions of hierarchical organizational structures, it is impossible to solve this problem. The method of using the faceted method of studying non-physical objects is shown in **Figure 1**.

The faceted method makes it possible to digitize and model non-physical supply chain management objects. Unlike physical management objects, non-physical objects are variable in quantitative parameters and qualitative characteristics. Therefore, their versions should be highlighted and their variants within those versions. Digitization of non-physical supply chain management objects is carried out in two stages. At the first stage, the researcher must identify possible versions and variants of the management object under study and assign a digital code to each of them. In the simplest case, this is a binary code. The binary code system allows you to establish relationships between versions and, accordingly, variants of an object before their computer modelling. When designing a digital supply chain management twin, binary codes are translated into machine codes, which in a digital environment help identify a version or variant of a non-physical object and their totality.

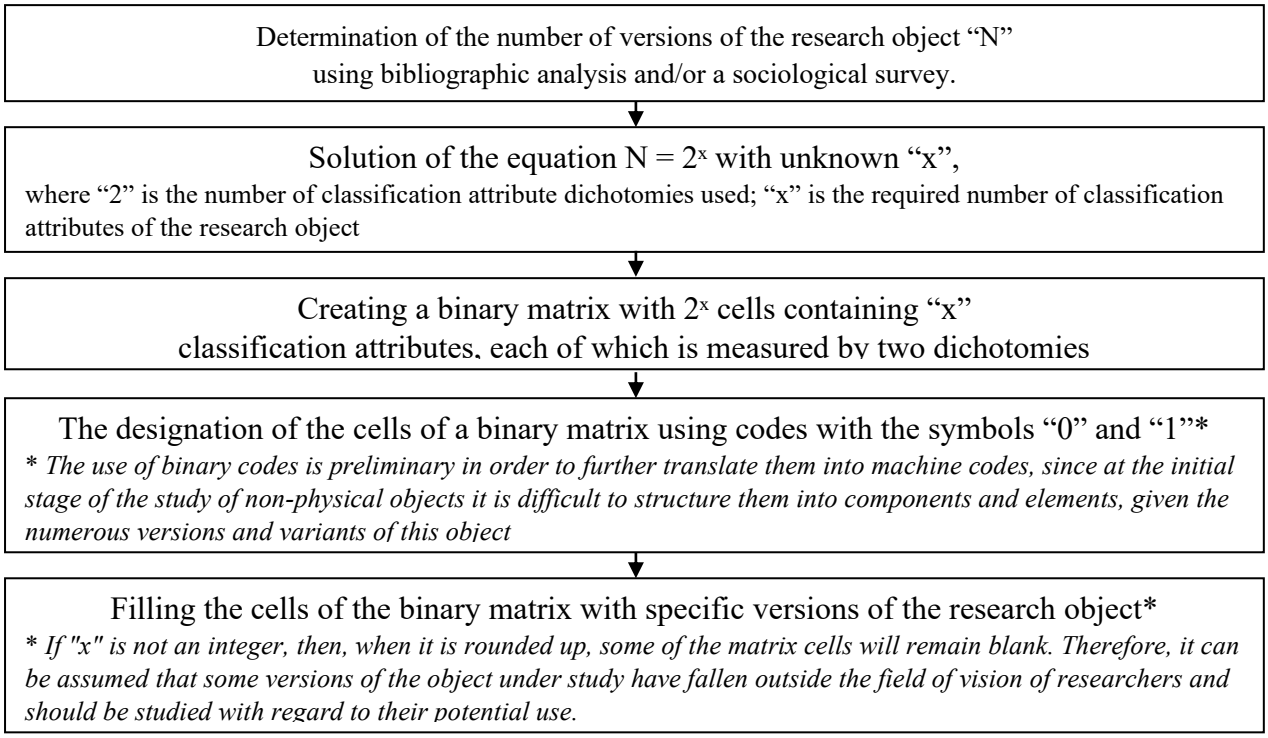

Figure 1. The technique of using the faceted method of studying non-physical objects.

One of the results of using the faceted method is a binary matrix developed by Tyapukhin[67]. This matrix presents the business processes of supply chain management proposed by Cooper et al.[68] based on three classification attributes and their dichotomies. The faceted method allowed not only to confirm the correctness of their classification, but also to supplement the list proposed by the authors with business processes such as technological and logistics management.

Collectively, terminological analysis, descriptive and faceted methods, or the TDF methodology provide the basis for identifying, formalizing, standardizing, structuring, combining, digitizing, and modeling non-physical supply chain management objects. The structure of the TDF methodology, which includes the stages of digitalization of objects of this type, is shown in **Figure 2**.

4. Results

4.1. Clarifying the essence of holacracy and digitalization of management of a link or supply chain

The supply chain is a specific object of management; therefore, it is advisable to clarify the essence of holacracy and identify its main difference from other management variants of a link or supply chain. To solve this problem, it is recommended to use the TDF methodology. Let us turn to **Figure 3**.

Figure 3 shows a binary matrix formed on the basis of two classification attributes that characterize the specifics of managerial decision-making at various management levels: at the organizational level, symbol "1" and at the division level, symbol "0". In addition, these decisions can be developed for standard or formalized ones, symbol "0", as well as non-standard, poorly formalized management situations, symbol "1". These classification attributes and dicho-tomies allow us to substantiate 4 variants for managing an organization in various management situations:

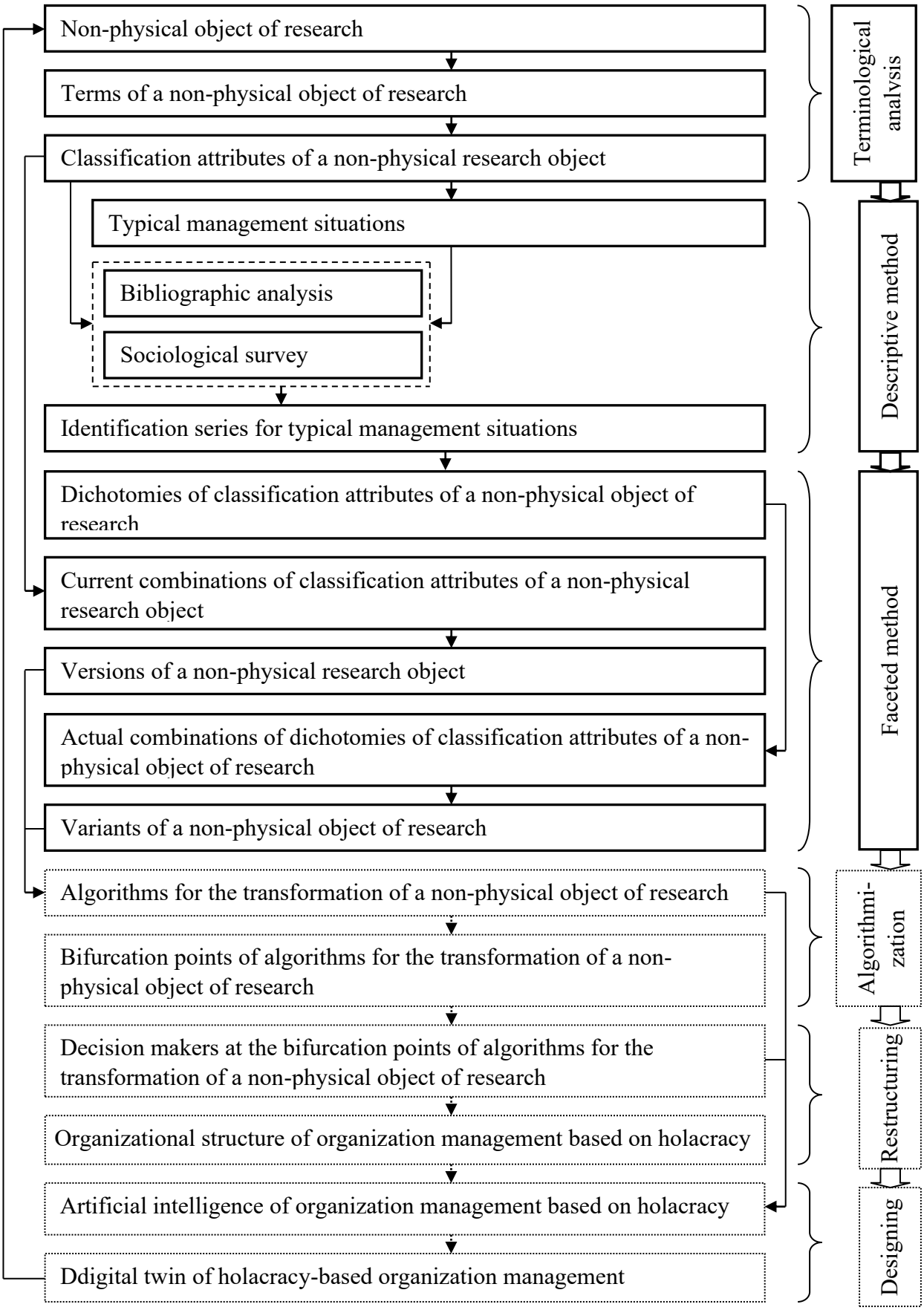

Figure 2. TDF-research methodology and stages of digitalization of supply chain management.

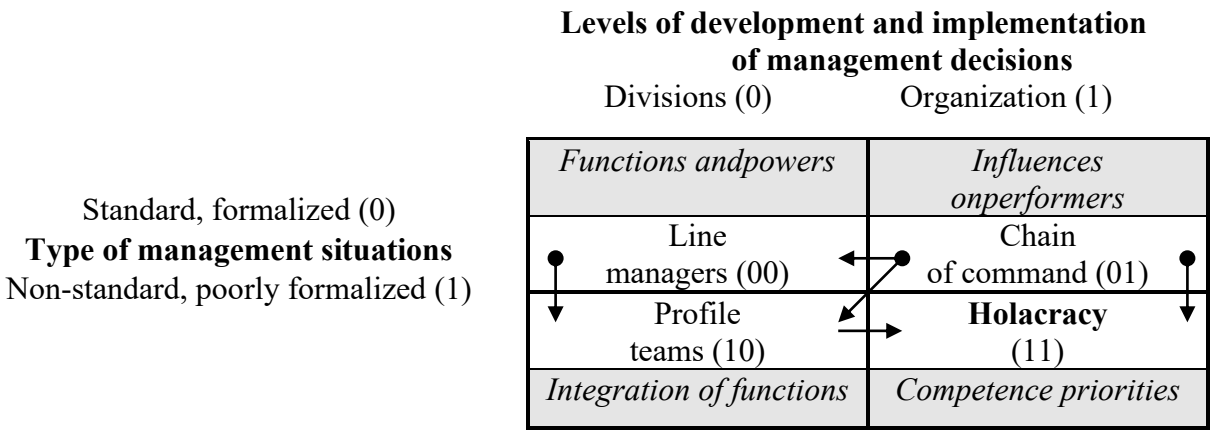

Figure 3. Classification of organization management variants in various management situations.

(1) involving line managers who have the powers and perform the functions of managing organizational divisions, code "00";

(2) creating profile teams in which the functions of the specialists involved in the teams are integrated, code "10";

(3) using chains of command of the "head–subordinate" type, providing for direct and indirect managerial influences on performers, code "01"; and

(4) introducing holacracy, that is, recognizing the priority of the competencies of persons most in demand in non-standard, poorly formalized managerial situations.

In addition, **Figure 3** shows the sequence of transformation of one type of organizational management into another, from chain of command to holacracy. This highlights the specifics of a particular option for developing management solutions, depending on the impact of external and internal environmental factors.

The closest to holacracy are the profile groups, which also differ in diversity or versions. The combined use of such classification attributes and dichotomies as "type of management decision": local, symbol "0", and global, symbol "1", as well as "type of approach to organization management": process, symbol "0", and situational, symbol "1", allows us to identify 4 types of profile groups: cross-functional, code "00", project, code "01", operational, code "10", and self-managed, code "11", groups (**Figure 4**).

Type of management decision
Local (0) Global (1)

Process (0)
Type of approach to organization management
Situational(1)

Cross-functional group (00)	Project group (01)
Operational group (10)	Self-managed group (11)

Figure 4. Classification of groups of employees of the organization.

With the digitalization of non-physical supply chain management objects, changes in the composition of these groups are expected, depending on the functions of the performers. This aspect of the research is reflected in **Figure 5**.

It can be seen from the contents of **Figure 5** that the self-managed groups that form the basis of holacracy include an artificial intelligence user, an operator, a researcher, a manager, and an IT specialist.

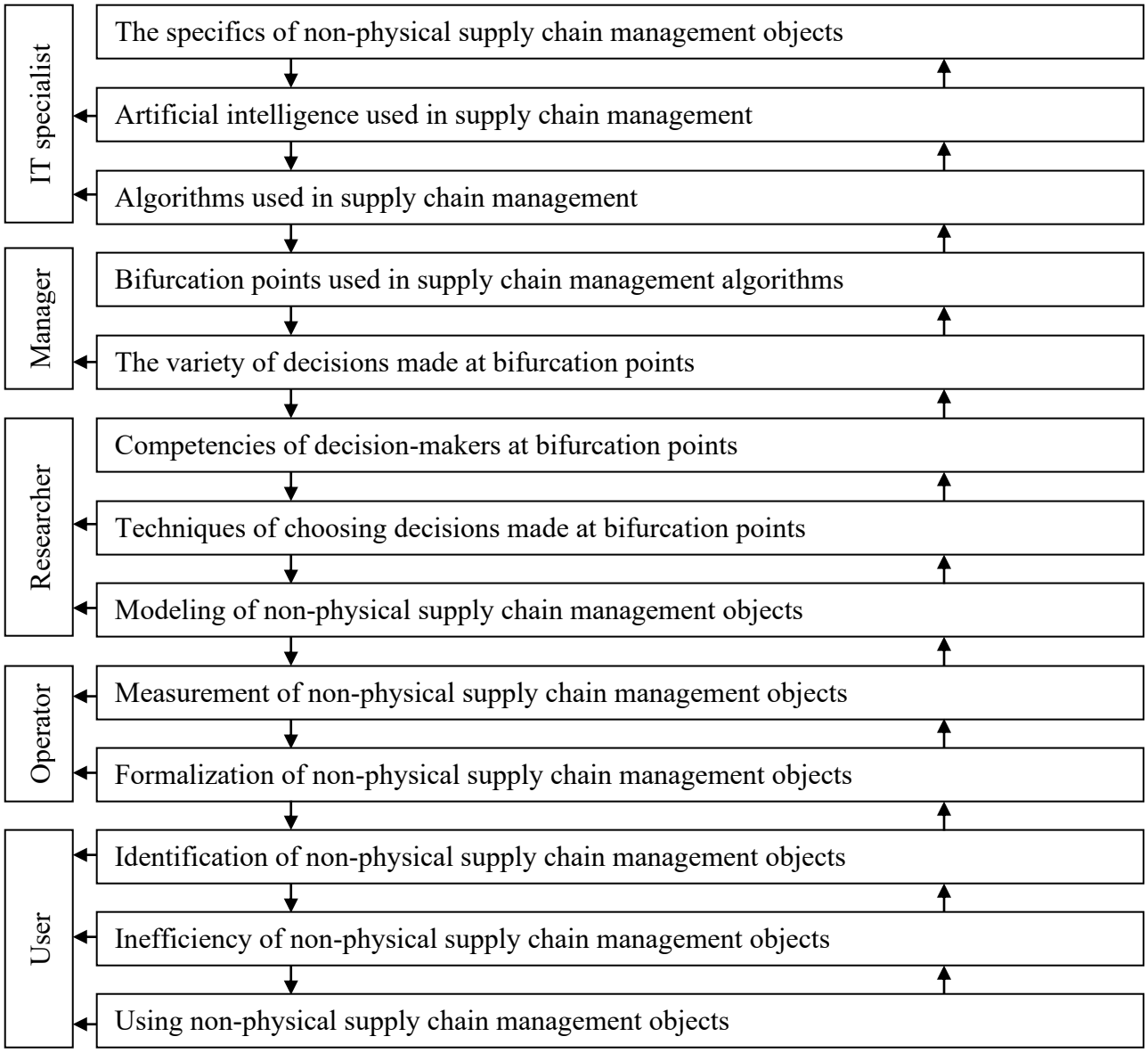

Figure 5. The functions of performers in the development of management decisions in digital supply chains in a holacratic environment.

The TDF methodology allows us to classify digital tools and their corresponding relations or supply chain management functions. To solve this problem, it is recommended to choose the following classification attributes and dichotomies: "time interval used to develop a management decision": retrospective, symbol "0", and perspective, symbol "1", as well as "form of the research convertible object": real object, symbol "0", and virtual object, symbol "1". The combined use of these attributes and dichotomies allows us to identify 4 traditional 4E digital tools and their functions: digital footprint, "secretary" function, code "00"; digital shadow, "assistant" function, code "10"; digital copy, "adviser" function, code "11"; and digital twin, "understudy" function, code "01" (**Figure 6**).

The information shown in **Figure 6**:

Firstly, it allows us to define the functions of the digital tools shown on it. In relation to a non-physical supply chain management object:

(1) a digital footprint is designed to identify an object in order to capture or display it in a virtual environment. One-way communication is used from a real, non-physical object to a virtual, non-physical object.

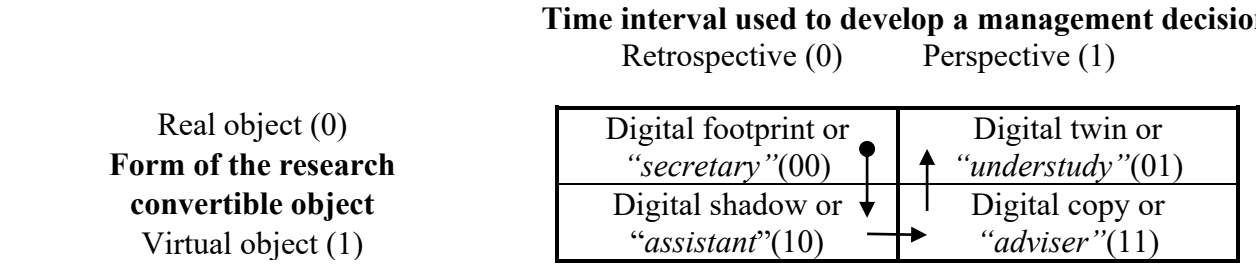

Figure 6. Classification of digital tools and their corresponding management functions of a link or supply chain.

(2) a digital shadow provides for the identification of versions and variants of a non-physical object in order to capture or display their totality in a virtual environment. One-way communication is used from a set of real non-physical to a set of virtual non-physical objects.

(3) a digital copy is designed to digitize versions and variants of a non-physical object and create its standards on this basis for their subsequent transformation into virtual copies adequate to unique non-physical objects of research. Two-way communication is used from a set of real non-physical to a set of virtual non-physical objects and vice versa to ensure their adequacy (identity) and interconnectedness.

(4) a digital twin provides the structuring and combination of virtual non-physical objects of research, followed by their modeling and the development of a management decision for their transformation. Two-way communication is used from a set of real non-physical to a set of virtual non-physical objects and vice versa to develop a management decision for optimizing real management objects.

Secondly, it suggests the possibility of the development of these digital tools, depending on their specific functions, which are necessary for a manager at a particular point in time. To address this issue, let's examine **Figure 7**.

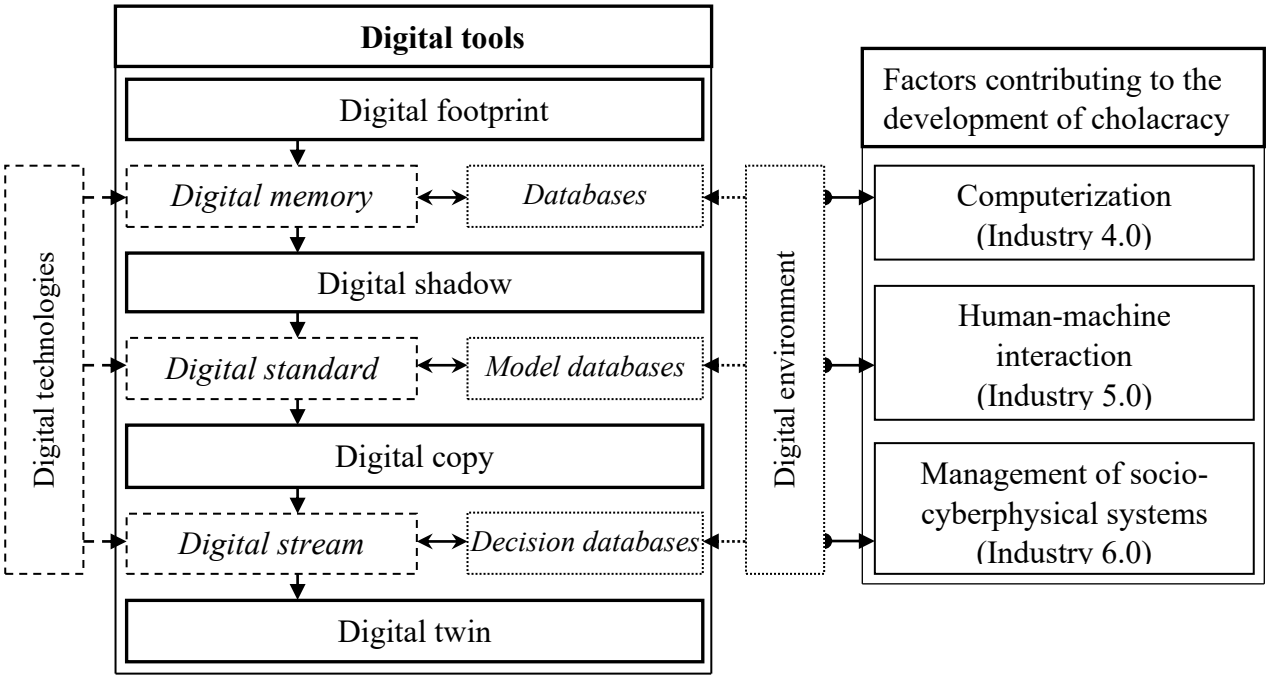

Figure 7. Classification of digital tools, technologies and components of the digital environment of a link or supply chain and factors contributing to the development of holacracy.

The analysis of this figure allows us to draw the following conclusions:

Firstly, digital tools (**Figure 6**) provide for the development and implementation of digital technologies that are deployed in a digital environment. This environment changes according to factors contributing to or hindering the introduction of holacracy.

Secondly, to convert a digital footprint into a digital shadow, it is necessary to use a technology such as digital memory[69]. Accordingly, when switching to a digital copy, digital standard technology is recommended[70], which allows modeling non-physical supply chain management objects. Finally, when creating a digital twin, digital copies are complemented by digital stream technology[71].

Thirdly, every digital technology implies the improvement of the digital environment. Thus, digital memory technology involves the creation of a database, digital standard technology requires the use of a model database, and digital flow technology relies on a database of management decisions.

Fourthly, databases are formed within the framework of computerization or the "Industry 4.0" concept, model bases are based on human-machine interaction as the priority of the "Industry 5.0" concept, decision bases are used in the management of socio-cyberphysical systems[72], most likely implemented within the framework of the "Industry 6.0" concept. This classification is not obvious and requires additional justification.

One of the most important aspects of implementing holacracy in supply chain management is the justification and digitization of the fundamental functions of the supply chain link. The solution to this problem is possible on the basis of the following classification attributes and dichotomies: "basic methods of holacracy": decentralization of management, symbol "0", and delegation of authority, symbol "1", as well as "prerequisites for the successful implementation of holacracy": creating a socio-psychological climate, symbol "0", and ensuring a process of developing management decisions, symbol "1". The binary matrix based on these attributes and dichotomies (**Figure 8**) allows us to assert that such functions are: motivation that takes into account the values of managers and employees, code "00"; acquisition of new competencies and teamwork skills, code "10"; liberalization of management and regulation of responsibility of managers and employees, code "01"; and development and implementation of collective management decisions, code "11".

	Basic methods of holacracy	
	Decentralization (0)	Delegation of authority (1)
Creating a socio-psychological climate (0)	Motivation that takes into account the values of managers and employees (00)	Liberalization of management and regulation of responsibility of managers and employees (01)
Prerequisites for the successful implementation of holacracy Ensuring the process of developing management decisions (1)	Acquisition of new competencies and teamwork skills (10)	Development and implementation of collective management decisions (11)

Figure 8. Classification of management functions of a link or supply chain in conditions of holacracy.

4.2. Digitization of supply chain options and supply chain management in a holacratic environment

It was previously stated that the main objects of supply chain management are enterprises (and their supply chain links and divisions), relationships, processes, and flows. Nevertheless, in order for artificial intelligence to process them in a complex manner, moving from one object to another, including without operator intervention, they must be digitized. The solution to this problem is shown in **Figure 9**.

State of supply chains within a link in time

Management options within a supply chain	Statics (0)	Dynamics (1)	
Value management (0)	*Enterprise's digital twin*	*Process digital twin*	
	Divisions(positions or roles)(00)	Processes (01)	Technology management (0001)
Resources management (1)	Relationships (10)	Flows (11)	Logistics management (1011)
	Digital twin of relationships	*Digital twin of flows*	
	Chain in statics (0010)	Chain in dynamics (0111)	

Figure 9. Classification of management objects, supply chains, processes performed by them, and digital twins of these objects.

It follows from the contents of this Figure:

Firstly, the divisions or positions (roles) of the managers and employees, together with the relationships between them, form the supply chain in statics, code "0010". In turn, processes and resource flows form chains in dynamics, code "0111". Both types of chains can be virtual or real chains.

Secondly, the divisions or positions (roles) of the managers and employees and the processes they perform create the prerequisites for technological management, code "0001", which creates value for end consumers of products and services. If we take into account the relationships and flows of resources, then the accompanying, but extremely important type of management for solving this problem is logistics management, code "1011".

Thirdly, each supply chain management object must have its own digital twin, and the digital twin of the product and/or service is developed within the framework of the digital twin of resource flows, since both the product and the service can be flow objects.

Fourthly, each of the supply chain management objects is a complex object, so it is advisable to isolate and digitize their components. The solution to this problem is shown in **Figures 10–12**. The features of **Figure 10** include:

Persons, responding to a management situation

Stages of development of a management decision	«Sensors» (0)	«Actuators» (1)
Preparation (0)	Inspectors (0000)	Researchers (0001)
Implementation (1)	Coordinators (0010)	Integrators (0011)

Figure 10. Classification and codes of positions (roles) or persons involved in the management of supply chain objects within their links.

Firstly, there is the classification of persons responding to a management situation into "sensors", that measure one or more quantitative parameters and qualitative characteristics of management objects, and "actuators", that affect these objects.

Secondly, there are two stages of developing a management decision: preparation and implementation of the decision.

	Stage of concretization of a management decision	
	Divergence (0)	Convergence (1)
Formalization of decisions (0) **Task of developing a management decision** Optimization of decisions (1)	Alternatives (1000)	Agreement (1001)
	Argumentation (1010)	Discussion (1011)

Figure 11. Forms of relationships between positions (roles) or persons involved in the management of supply chain objects within their links.

	Persons with decision-making authority	
	Employees or Subordinates (0)	Managers or Leaders (1)
Real object (0) **Form of a study object in management** Virtual object (1)	Monitoring of a management object (0100)	Impact on a management object (0101)
	Study of a management object (0110)	Management decision(0111)

Figure 12. Classification and codes of processes affecting the supply chain management object.

Thirdly, there is the differentiation of positions (roles) or persons involved in the management of supply chain objects within their links. These persons (roles) include inspectors, code “0000”, and coordinators, code “0010”, researchers, code “0001”, and integrators, code “0011”. Moreover, coordinators are managers of lower and middle management levels or leaders of profile groups who, within their competencies, receive information from inspectors and transmit it to integrators—persons at the highest level of management or higher leaders, as well as those called upon to implement management decisions received from integrators. In turn, researchers model management situations and determine a rational combination of quantitative parameters and qualitative characteristics of management objects (**Figure 9**), which is subsequently either approved or finalized by integrators.

The binary matrix shown in **Figure 11** is based on the following classification attributes and dichotomies: “stage of concretization of a management decision”: divergence, symbol “0”, and convergence, symbol “1”, as well as “task of developing a management decision”: formalization of preliminary and final decisions, symbol “0”, and optimization of interim management decisions, symbol “1”. Using this binary matrix allows us to identify 4 forms of relationships between positions (roles) or persons involved in the management of supply chain objects within their links, such as: development of alternative or local management decisions, code “1000”; argumentation of the points of view of these persons, code “1010”; discussion of the strengths and weaknesses of these points of view, code “1011”; and the coordination of a common management decision and its structuring vertically and horizontally within the organizational structure of management.

Since relationships are extremely complex, non-physical supply chain management entities are identified by the indicators presented in **Table 2**.

Figure 12 allows us to identify 4 main processes of impact on the supply chain management object: monitoring of the management object (the prerogative of inspectors and coordinators), code “0100”; study of the management object by its components and in general, code “0110”; development and adoption of the management decision, code “0111”; and impact to the management object, code “0111”. As follows from the information in **Figure 12**, these processes are performed by employees (subordinates) and managers (leaders)

operating with either a real or virtual management object. In this case, the following identification series is used: (1) "persons with the authority to make managerial decisions, and (2) form of the supply chain management object". It should be noted that during each process, one or another form of relationship is possible (**Figure 11**).

Table 2. Main indicators for identifying the forms of relationships between positions (roles) or persons involved in the management of supply chain objects within their links.

Relationship type	Form of participation	Opponents' alternatives	Initial decision	Result
Alternatives	Individually	No	Grounded	Conviction
Argumentation	Individually	Yes	Defended	Criticism
Discussion	Collectively	Yes	Adjusted	Doubt
Agreement	Collectively	Yes	Finalized	Compromise

Similarly, material, information, financial, and human flows can be distinguished[8] which in this case are recommended to be designated by codes, respectively, "1100", "1101", "1110", and "1111".

The information presented in **Figures 10–12** allows us to digitize and model the main types of supply chains, as well as their management (**Figure 9**). For example, **Table 3** shows the options for supply chains in statics and their binary codes. In the process of modeling chains of this type, the participation of inspectors in the development of alternatives is indicated by the code "1000.0000"; if the integrators agree on management decisions, then this chain has the code "1001.0011".

Table 3. Options of supply chains in statics and their binary codes.

Relationships of positions (roles) or persons involved in the management of supply chain objects (Figure 11)	Persons involved in the management of supply chain objects (Figure 10)			
	Inspectors (**0000**)	Researchers (0001)	Coordinators (0010)	Integrators(0011)
Alternatives (1000)	1000.0000	1000.0001	1000.0010	1000.0011
Argumentation (1010)	1010.**0000**	1010.0001	1010.0010	1010.0011
Discussion (1011)	1011.0000	1011.0001	1011.0010	1011.0011
Agreement (1001)	1001.0000	1001.0001	1001.0010	1001.0011

In turn, **Table 4** shows the options for technological management in the management of supply chain links. For example, when examining the management object by inspectors, one needs to use the binary code "0110.0000". Similarly, the code "0111.0011" is recommended to designate the development of a management decision by integrators.

In addition, **Table 4** shows 2 options for the development and implementation of man-agement decisions. In the first option, inspectors, regardless of external influence, monitor the management object, code "0100.0000", study this object, code "0110.0000", make the management decision, code "0111.0000", and influence the management object, code "0100.0000". In the second option, the inspectors, based on the results of monitoring the management object, code "0100.0000", transmit the information received to the coordinators, who summarize this information, code "0100.0010", and bring it to the attention of the integrators, code "0100.0011". The integrators study the information received, code "0110.0011", and then transmit it to the researchers, code "0110.0001". The researchers model the management situation and develop several variants of structured management decisions, code "0111.0001", which they send to the integrators. Integrators make the final management decision, code "0111.0011", if necessary, structure it at their discretion, and send local management decisions to the coordinators. The coordinators impact the management objects, code "0101.0000", informing the inspectors about this.

Table 4. Options for technological management in the management of supply chain links.

Processes of influence on a management object (Figure 12)	Persons involved in the management of supply chain objects (Figure 10)			
	Inspectors (0000)	Researchers (0001)	Coordinators (0010)	Integrators(0011)
Monitoring of a management object (0100)	0100.0000	0100.0001	0100.0010	0100.0011
Study of a management object (0110)	0110.0000	0110.0001	0110.0010	0110.0011
Management decision(0111)	0111.0000	0111.0001	0111.0010	0111.0011
Impact on a management object (0101)	0101.0000	0101.0001	0101.0010	0101.0011

Example 1 Example 2

4.3. Development of technology for the interaction of positions (roles) or persons involved in the digital management of an organization in a holacratic environment

When implementing digital technologies and tools in a digital environment (**Figure 7**), it is necessary to make significant adjustments to the process of developing and implementing management decisions by a link or supply chain.

Figure 13 shows the scheme of the interaction of positions (roles) or persons involved in the digital management of supply chain objects according to the "line managers" option (**Figure 3**).

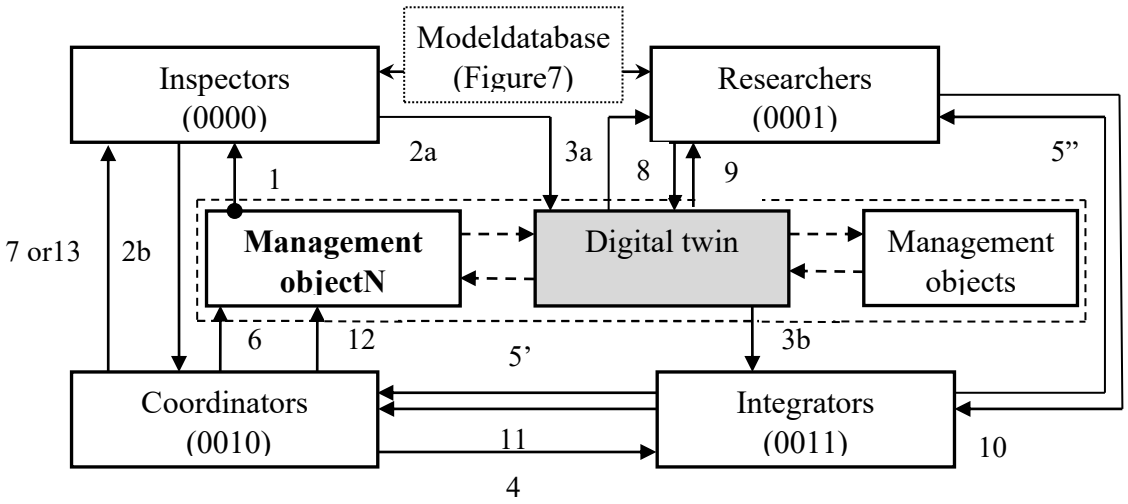

Figure 13. Scheme of interaction of positions (roles) or persons involved in the digital management of supply chain objects (option "line managers", Figure 3)

The basis for the development and adoption of management decisions in supply chains is the digital twin operating with physical and non-physical objects. Therefore, in the case of critical deviations of one or more management objects from their planned parameters and characteristics, the digital twin should be able to assess the impact of these deviations on the effectiveness of supply chain management in general.

The interaction of positions (roles) or persons involved in the digital management of supply chain objects is presented as follows. Inspectors monitor the condition of the management object (arrow 1), for example, relationships, and enter its real parameters and characteristics into the digital twin (arrow 2a). Manual input of these parameters and characteristics is especially important for non-physical management objects, since the inspectors act as "sensors" in this case (**Figure 10**). In case of critical deviations of the management object from the planned condition, the inspectors bring the information they receive to the

attention of the coordinators (arrow 2b). Monitoring of the management object using the digital twin is performed by researchers (arrow 3a) and integrators (arrow 3b). If the coordinators propose a management decision for its implementation, they should request the necessary resources from the integrators (arrow 4). Integrators, comparing information from the digital twin and from the coordinators, can approve this decision and allocate the necessary resources for its implementation (arrow 5'). The coordinators, using the allocated resources, impact the management object (arrow 6), informing the inspectors about it (arrow 7). If the integrators are not sure of the effectiveness of the decisions proposed by the coordinators, they give the researchers a task to model the required management decisions (arrow 5"). Researchers use the digital twin (arrow 8) to complete this task (arrow 9) and offer integrators several management decisions (arrow 10), while replenishing the database of supply chain management models. Integrators select and, if necessary, adjust the final decision, bring it to the attention of the coordinators, and allocate the resources necessary for its implementation (arrow 11). The coordinators impact the management object (arrow 12) and inform the inspectors about it (arrow 13).

With the introduction of holacracy, the interaction scheme of positions or persons involved in the digital management of supply chain objects is simplified (**Figure 14**).

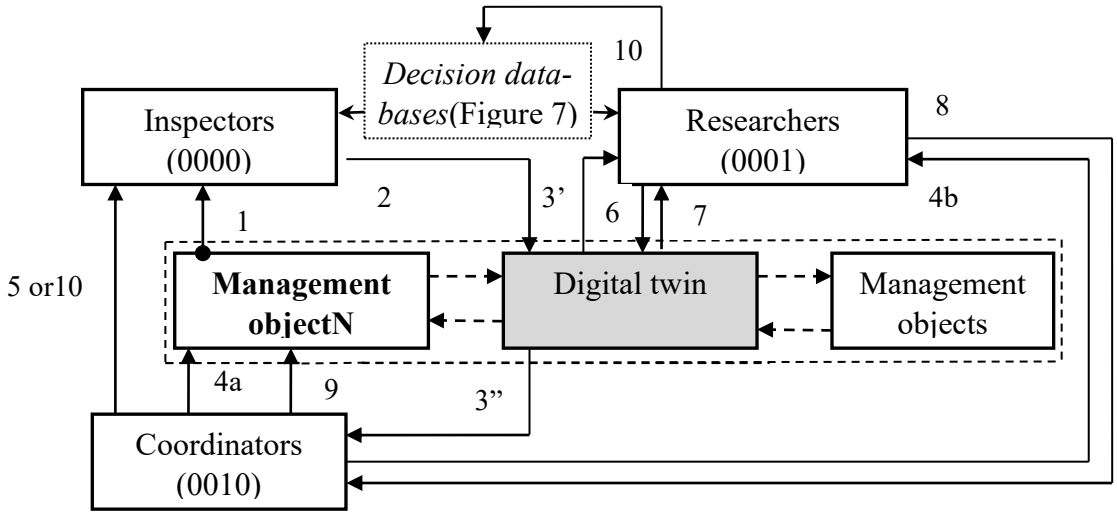

Figure 14. Scheme of interaction of positions or persons involved in the digital management of supply chain objects (option "holacracy", Figure 3).

The features of this Figure include:

Firstly, the exclusion of integrators, whose powers and functions are transferred to the coordinators. At the same time, the intellectual capabilities of digital technologies, tools, and the digital environment should be qualitatively different from their capabilities under the "line managers" option.

Secondly, the creation and use of not only the model database (**Figure 13**), but also the decision database based on the standards of management objects and management decisions (**Figure 7**) used by the digital twin of supply chain management.

Thirdly, the ability of the coordinators to make and implement management decisions remains without the involvement of researchers, or with their participation.

Fourthly, there is a certain potential for excluding coordinators from the process of developing and implementing management decisions; however, the solution to this problem depends entirely on the potential of artificial intelligence (digital twin) operating with non-physical management objects.

4.4. Justification of the approach to making digital management decisions in supply chains based on holacracy

The feature of this section is the rationale for the need to move to holacracy, which provides not only decisions to individual supply chain problems, but also the introduction of global strategies such as business

process management (e.g.,[73]). We will demonstrate the approach to making digital management decisions in supply chains based on holacracy using the example of the Deming cycle[74]. Recall that the Deming cycle includes 4 processes: "Plan – Do – Check - Act".

In the study, the operation structure was developed for each of these processes, which is typical for an abstract machine-building enterprise. **Figure 15** shows a fragment of the study, which contains the sequence of operations of the "Do" process of the Deming cycle.

These operations are located around the perimeter of the figure. In the center of this figure are the supply chain divisions responsible for performing these operations. Each of the divisions performs a specific operation individually or jointly with other divisions.

For example, **Figure 15** shows that the operation "Development of production process schedules" is performed by employees of the manufacturing and dispatch departments, and the operation "Transfer of products to the trading links of the supply chain" requires the joint participation of employees of the sales department, accounting department, logistics management department, and sales links of supply chains. When performing this operation in a link with a hierarchical structure, the divisions listed above, as a rule, consistently perform their functions within the limits of their authority. In conditions of holacracy, the operation "Transfer of products to the trading links of the supply chain" can be performed by an operational group of specialists (**Figure 4**) formed on the basis of those departments that must perform this operation. That is, this group resembles a project group, but performs its functions only to perform one operation, after which a new operational group of specialists is created to perform the next operation of the "Do" process. In **Figure 15**, such an operation is the "Loading and transportation of products" operation, which must be performed by specialists from the logistics management and marketing departments, and marketers are required to inform the trading links of the supply chain about the completion of this operation. The "Plan", "Check", and "Act" processes of the Deming cycle can be represented in a similar way, and not only that.

Thus, the holacracy-based approach to digital management decision-making in supply chains involves specific operations of global processes performed by operational groups of specialists involved in their various supply chain divisions. Moreover, these groups function sequentially and in parallel, changing qualitatively and quantitatively. In other words, we are talking about creating flows of operational groups, the goals of which are to eliminate interoperative and cross-functional barriers by reducing process execution time and, consequently, creating more effective value for end consumers of products and services. This means that the basis of holacracy is logistics (logistics management)[75].

5. Discussion

Digitalization and holacracy are two promising trends in supply chain management. While success in digitalization depends on external factors such as the level of digital technology development and the availability of tools and digital environment, success in holacracy is more dependent on the internal environment of each link in the supply chain. In reality, this chain is a horizontal-vertical structure in which horizontal links are implemented between adjacent links in the supply chain, and vertical links are implemented through a chain of command of a "manager – operator – machine" type. This article substantiates recommendations for replacing the chain of command with self-managed organizations formed on the principle of providing products and services when needed. A similar approach is observed in the interaction between adjacent parts of the supply chain. The consumer of products and services initiates demand and transfers the authority to fulfill it to suppliers who will do it in the best possible way. Thus, this consumer initiates the creation of several "circles" in order to fulfill this demand. In turn, "circles" of lower levels are created within each "circle", as the components of the demands are structured with consideration for various managerial and technical aspects. In other words, the principles of interaction of organizationally separate, adjacent links of the supply chain, as they become ready, extend to their internal environment, gradually transforming hierarchical management structures into structures of self-managed teams.

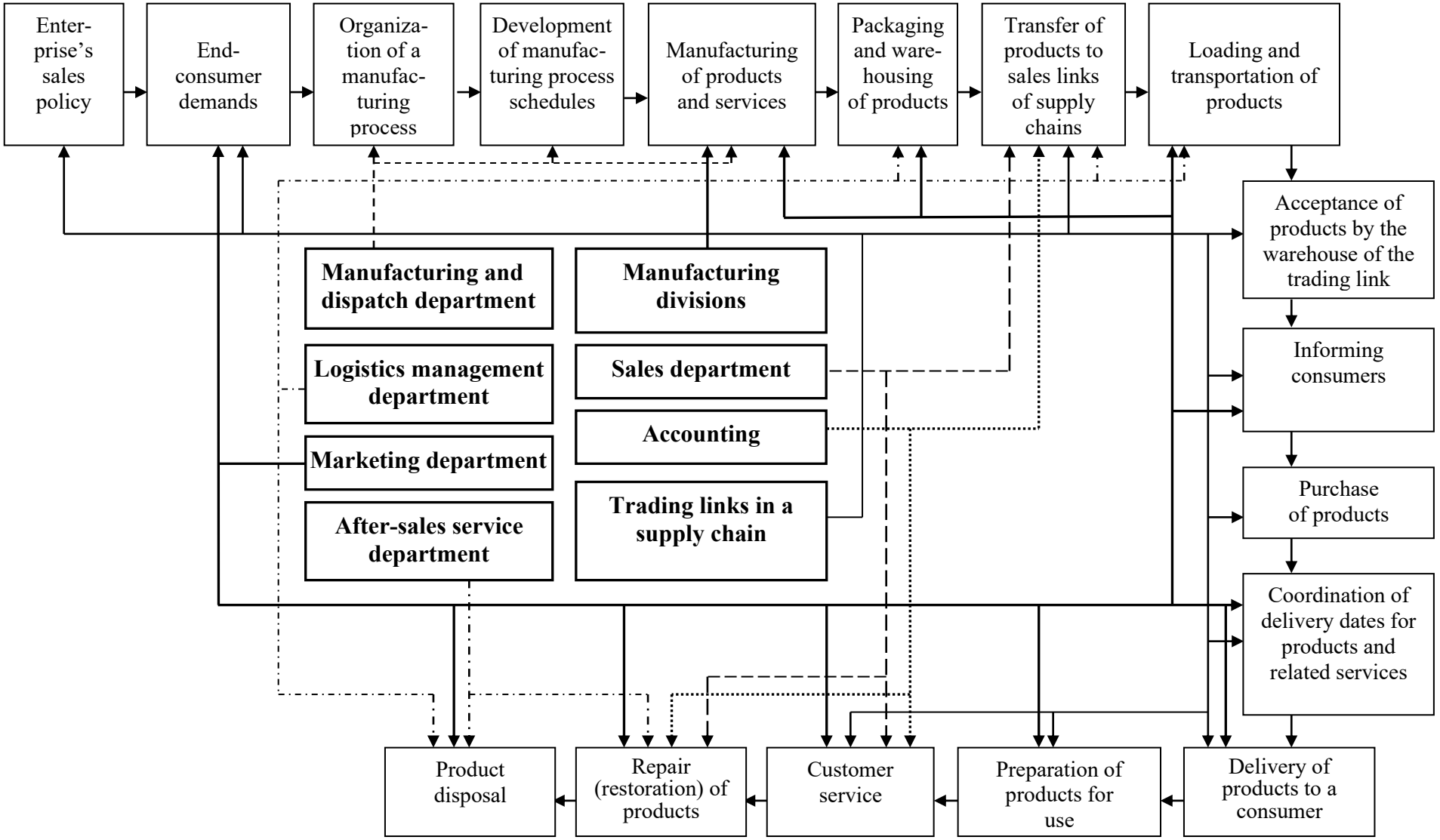

Figure 15. Structure of the "Do" process of an abstract machine-building enterprise.

Holacracy is still an exotic concept of organizations, not to mention supply chains based on them, so many of its theoretical and methodological aspects are debatable. These aspects include: prospects for the use of holacracy at the junctions between supply chain links; technologies for the interaction of employees from various divisions of the supply chain in project and operational groups operating on the principles of self-organization and self-management; methods of identification, formalization, standardization, structuring, combination, digitization, modeling, and optimization of non-physical supply chain management objects; structure and methodology of designing artificial intelligence operating with physical and non-physical management objects; organization of interaction of persons making managerial decisions using the digital twin of supply chain management; theoretical and methodological aspects of managing not only supply chains but also value and demand chains; issues of sustainability of chains of various types in conditions of holacracy, etc.

Consideration of the above aspects is constrained by a number of factors.

Firstly, in digitalization, the introduction of which causes a growing imbalance between research and optimization of physical and non-physical facilities. If this imbalance is not eliminated, there is a real threat of a "machine uprising", whose artificial intelligence will be directed against humans as the main source of their problems and disasters.

Secondly, in human resource management, due to the underestimation of its potential for organizing the work of self-managed teams. So far, the idea of holacracy has not created a critical mass of supporters, which limits the potential for digitalization of supply chain management.

Thirdly, in the terminology of various spheres of human activity, including supply chain management, the state of which prevents the clear identification of non-physical objects characterized by variability of structure and content.

Fourthly, in the methodology of research of supply chain management objects, focused on empirical research methods, which focus on some average opinion of a group of specialists or an average model. Both can be far from the real values of their possible users, since each “value is always intangible, heterogeneously experienced, co-created and potentially perishable”[76].

6. Conclusion

The contribution of the obtained results to the theory is due to the creation of prerequisites for the formation of the theory and methodology for the implementation of holacracy in supply chain management, ensuring the practical application of artificial intelligence operating on physical and non-physical management objects. This artificial intelligence is the basis of the digital twin of supply chain management, aimed at minimizing lost profits in chains of this type. Lost profit is not estimated immediately, but after some time, when unknown factors are identified or clarified—ignorance or disregard of which provoked previously unplanned losses. Therefore, empirical studies and methods of processing the results obtained are necessary to calculate this indicator.

The contribution of the study results to practice is confirmed by the possibility of extending the holacracy methodology to linearly ordered enterprises, relationships, processes, and flows, including flows of operational groups, which helps to reduce the time for creating value for end consumers of products and services, as well as employees of these enterprises, who fully reveal their competencies and potential.

In the future, it is planned to substantiate the goals, objectives, principles, approaches, methods, and functions of holacracy in supply chain management; clarify and supplement the theory and methodology of supply chain management based on holacracy; identify the features of the development and implementation of holacracy in the management of value and demand chains; work out the methodological and practical aspects of creating artificial intelligence operating physical and non-physical objects of supply chain management; and offer recommendations for the formation of structures and the choice of methods for designing prototypes and instances of digital twins of enterprises, relationships, processes, and flows.

Conflict of Interest

The authors declare no conflicts of interest.

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